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**INTERVIEW WITH DR. GEORGE MCDONOUGH**  
**INTERVIEWED BY DR. STEPHEN P. WARING**  
**20 AUGUST 1990**  
**HUNTSVILLE, AL 35802**

1. MCDONOUGH: ...they had a job fair, I didn't go, I wasn't interested in NASA. I didn't even think about NASA. I was working on Air Force projects. But a couple of people that worked for me went and they came back and said, "Well, NASA didn't have anything for them, but they were looking for me. They described what you do just perfectly. They are really looking for someone like that." I still wasn't interested. They went and got me this Form 57, I think it was 57 at that time, to fill out. They badgered me really, so I filled it out and sent it in. I heard from JSC, Marshall and Lewis. I wasn't too interested, but it got me thinking about changing jobs, which I hadn't really thought about. I called about the same time by the University of Notre Dame. They had a teaching position open and they were looking for me because the work I had done in graduate school was something that they were getting into. Anyway, one thing led to another. I got more serious about leaving anyway. However it happened. So, since my wife's mother is from Mississippi, I got a lot of pressure from home too. So I finally came and interviewed with Marshall. I met Helmut More [? 20] and some of the people, and really was impressed. I was really surprised that I would be that impressed, but the work was good and von Braun was here. I went back and really thought seriously about it after that. But it took me 6 months before I finally decided to come. I think I would probably have gone to Notre Dame except my wife wouldn't do it. So I had to decide whether to stay married or do something else.

I came here as a section chief in structural dynamics down in the Aerodynamics Laboratory. I also was a deputy branch chief in the dynamics and flight mechanics branch at the same time. It was a lot of fun. Nineteen sixty-three was a good year. All kinds of things going on. I took over a job as the secretary of the dynamics working group. I made decisions about dynamic testing of Saturn vehicles. What test you run, what instrumentation you put on. It was just a lot of fun. I got to meet von Braun. I was here

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about a month, maybe, and I got to make a little presentation to von Braun. That was really a thrill!

But I stayed in that job until sometime in early 1967 or 1966. I came in August, 1963. It was probably March of 1966 that I was promoted to a Deputy Division Chief. I kept that job until about the first of 1968. What happened to me was that Helmut and I tried to share the job. I took some aspects and he took others. I took AAP, the Apollo Applications, something I was going to follow. He took all the Saturn things. I took more of the forward thinking. He took more of the bread and butter ones. I got all involved in these programs. Finally they asked me to come to the program office. They set up a new organization under <sup>e</sup>Le~~X~~ Belew with George Hardy going to be in the systems engineering office as the head of it. I was going to be the top S&E guy as his deputy. So I decided that was a big challenge to go and do that. So I did.

2. WARING: You continued in that role through the Apollo Program?

3. MCDONOUGH: No, a lot of things happened before that. I moved over to <sup>Ludy</sup>~~Rudy~~ Richards operations, Systems Engineering office. Hardy and I were suppose to report to both Belew and to <sup>Ludy</sup>~~Rudy~~ Richards. Both to the Project Office and to the Systems Engineering. I was sort of the systems engineering man in the joint office and Jordan was the project manager. But you know one thing or another we never really got organized. We stayed in that mode, but I stayed over at S&E and he stayed over in the project, just because of the <sup>Vagaries</sup>~~vagaries~~ in trying to form such a place. It took so damn long that we decided to do something else before we ever...

The next thing they did was to form... von Braun decided to try to do systems engineering differently. They formed central systems engineering. The function I was doing inside that joint office then went to central systems engineering and I was an office chief. Dick Smith and I were the two. Dick had the Saturn projects and I had Apollo

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Applications projects. Just before this time, I led the small group that was doing a secret assessment to try to go from the wet workshop to the dry workshop. Instead of launching a Saturn I in use as a live stage, we are going to use Saturn V.

4. WARING: Why was it secret?

5. MCDONOUGH: I think because George Mueller, who was head of space flight, didn't want to get embarrassed if it didn't work out. So it was all done, supposedly quiet. If you knew George Mueller, he wasn't very good at quiet. We used to go down. There were only three of us here working on it, or four of us; Jim Glover, Charlie Davis, Dick Gregwisch [88], and I pulled this whole thing together. Rudy would take us to see George Mueller. Usually he would have his secret meetings at the Cape. It was interesting. We would go down to the motel. Half of Marshall is staying at the same hotel. Mueller wants to meet at the pool. He would sit there in his bathing suit. You would come with your charts. Everybody is looking at you like, "who are these people, what are they doing here?" In case nobody knew that it was Mueller, he would be paged for telephone calls, occasionally. We worked something out.

6. WARING: Let me see if I get this right. This is an interesting story. Mueller was in favor of the wet workshop?

7. MCDONOUGH: No, the dry workshop. Mueller wanted the change because he didn't think the wet workshop was viable. He had Saturn V available, so why jump through this kind of a hoop when you have an easy way to do it? But the center didn't want to change. We were pariahs [102] around here for wanting to do it because it was really considered by a lot of the people as a slap to them, that they couldn't pull this off so they had a new way of doing things. Besides, they had secretly planned to never have it work anyway. They

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had the ATM, the Apollo Telescope Mount, was designed so that it could be launched separately. It didn't have to go with the workshop. The workshop didn't need it either, so they could have separate launches and have separate missions. So a lot of intrigue.

8. WARING: Why do you think the center stayed with the wet workshop idea so long?

9. MCDONOUGH: Well, we didn't have any alternatives. Mueller thought, in fact he drew it on the board up there one day, just in the middle of meeting, but we were doing it, that was all that anybody. We didn't think we had Saturn V's. We figured the program would go on and <sup>there</sup> ~~their~~ were plans for a I-B. We didn't know that Saturn was going to come to an untimely end like it did. We had no idea. We had plans to launch them by the hands full. That is why we had the big BAB to crank them out.

There was a lot of resistance to it, so he kept the lid on it. We made a presentation at headquarters. A lot of questions came up. Actually, there was a lot of anger at those of us doing it. The head guy at JSC was Bob Thompson, who later managed the shuttle. He got so angry at me one time he wanted to go out and fight. Really. We made a presentation about something that he couldn't, didn't like.

Finally, von Braun forced the issue. We had a little round table. One of von Braun's favorite things up in the 9th floor conference room. I was in there, a whole bunch of the lab directors. All of them, the big wigs. I was the lowest yard-bird in the room. Von Braun said, "Mueller's been leaning on them and that he had to go back and tell them something, what should he tell them?" Its funny. He started around the table and <sup>L</sup> ~~R~~ Rudy was the first one. He was the big proponent, he had gotten me into it. He hemmed and haaed, and said "well I guess if people don't want to go with it we ought to stay with the old one." He came around the table, people were looking at him because they were expecting to be supporting him after he went for it. They got to me and I told them that I didn't think that was good enough. Mueller wasn't going to take a yes or no. If you tell him that you

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didn't want to do it, why he thought he could do the old one. Well people thought that was a good idea. We went around the table and von Braun said that he decided that we would have a meeting the next day to tell them about comparisons about the two so that he could talk intelligently about it. My boss was Walter Hausserman, who was probably the worst systems engineer who ever took a breath. I don't know if you ever knew Walter, but, he is one of the best, most brilliant people that I ever knew in my life. Really brilliant, really encyclopedic knowledge of the gyroscopes and things like that. They put him in that job because he had come up with a great compromise between the two groups. One of whom wanted no systems engineering and the other wanted everything systems engineering. So he said, "We can have some of each." So they all bought that.

Walter didn't have any idea what the game was at this time. He called me in his office the night before the meeting, about 7 o'clock and told me that I couldn't give the presentation that I thought I was going to give, which I had all prepared by that because it was all day the next day, that I could only talk about what was wrong with the wet workshop. I couldn't talk about the dry workshop. All the guys were still in my room, I didn't let anybody go home. So we built the pitch from the rest of that time between then and 11 o'clock sometime, and gave it to von Braun. At noontime when he went back with a lot of his cohorts had come back from a staff luncheon. He said, "That wet workshop is a can of worms." That was the end of it. No more tax. When von Braun went that way, everybody else went that way. So we went with the dry workshop. Houston agreed reluctantly. Gilruth didn't want it because, actually they tried to kill the wet workshop. They wanted to kill the whole program because they had this airplane that we built, the shuttle without the wings. The workshops didn't do anything for them.

In fact, just as an aside, one very interesting meeting up there one of these sassy <sup>[astronauts]</sup> Apollo, the first seven astronauts that were up there holding forth about how they weren't going to use the workshop anyway. They stayed in this multiple docking adaptor where they had places for experiments and they were just going to keep the experiments there

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because they were moist there, they couldn't be raunchy wet. Von Braun asked them a couple of questions. Finally he said, "well I think I understand what you want from this workshop. I will tell you that I don't support such a workshop. I just withdraw my support on this project." The guy did backflips. It wasn't only Marshall. When von Braun went, everyone went.

That is a long way to get to the story that we went on with this thing. In late 1968, Mueller asked for me to go to Washington to be on his staff. I would have been the first shuttle employee, I think. So I moved up here as an assistant to the Director for Science and Engineering, under Wagner. I got up here and settled, they did things in a gracious way in those days. The deal was you would come up here and they would give you an office, which is just next door over here, and you would go up and try it for a month or two. If you liked it alright then we will sign you on for a year, you go on TDY for a year. After a year if you want to stay your gone and if you want to come back, no questions asked just come on back. So I get up here and I guess it was about November. I was hardly up here and the changed the whole organization that I was in. My job more or less, just disappeared. Mueller retired, resigned. I was left up here. So I stayed in the Director's office for a couple of years. I can't remember when Nixon finally got religion about the environment and said he was going to do something about it, they formed the Environmental Applications Office. I was made head of that. That pulled together all of the remote sensing work, the environmental stuff that we did. All the environmental monitoring around here. About that time the first resources technology satellite was going up and we had all these projects with the local states, Tennessee, Kentucky, Georgia, Florida, until we got the Cape's reaction, Louisiana. We had projects in all those states. We got a fair size remote sensing program going. That lasted until... [111 Strange noise on the tape] I hate to say it, but I think he came with the express intention of destroying the laboratory structures as it was. So he reorganized the labs.

10. WARING: Why do you say that was his intention?

11. MCDONOUGH: I think that it was clear that he came down here to get rid of the Germans. Break the back of that close relationship between center director and the lab directors. That was the next, if you look at von Braun, the next line of organization under him was lab directors. Herman <sup>Wiedner</sup> ~~Widener~~ was here in this office, but he was just another one of the guys. Von Braun wouldn't have <sup>to</sup> go to him to go to the lab directors to get answers. Von Braun was the organization. They had their own stats <sup>[staffs?]</sup>. They had their own procurement offices. All these things, personnel offices and all that. I even heard the term, which wasn't suppose to be outspoken, called Superdivisions. They stripped all the administrative functions out of the laboratories. They split the old astronautics laboratory into data systems, I forget what they called them. They use to call them Astronautics East and West. They put us over in... Let me say that one of the jobs during the reorganization, I was given the job to organize the data systems lab, to put together the plan for ordering that laboratory. Which I did. Then they put me in that lab as deputy to J. T. Powell, who was head. I was also in... You know it is confusing! I haven't thought about this in years, so I am probably rambling. But anyway, all this remote sensing work that we had to do, we started finding out that the most serious problems in the whole program we had dealing with the other states and all the federal agencies, all these people that we dealt with, wasn't the remote sensing, it was the management of the data that came from the remote sensing. So we got all interested in data management and how we take care of that part of the program. We started a data management program, which Petrone fostered, I would say, because an old friend of his, Willis Willowby was the manager of headquarters. So we started building this program up. So I went over there in a dual function. I was the program manager for what they wanted in the lab. So I was sitting in the lab as deputy to J. T. That went on for a few years until about 1978. Finally killed the data management program because after Petrone left Lucas became Director. He didn't like the program for

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whatever reason. There were a lot of reasons not to like it I guess. It was tough. It was a tough program for us to do. It finally got killed about 1977 or 78.

Then I was transferred up to the Chief Engineers Office under Bob Marshall. I was the Deputy Associate Director for Engineering. I more or less watched over the manned shuttle things, especially experiments and things like that, getting those on, plus acting as Deputy. So I did that until about 1981, just before the first shuttle launch. I went down to systems Dynamics Laboratory. [177 ?]. It was maybe a month or so before the launch. I stayed there until two years ago. I had a real good run there. That was the best job I think I had. In a lot of ways it was better than this job. It was a love affair for me.

12. WARING: The systems dynamics job? What did that involve?

13. MCDONOUGH: Well, it changed radically over the years that I had it. When I first went down there they had just removed one division. They had the Jack Lucas' simulation division in there to take care of all the computers for everybody. It moved back to the astronautics, or whatever lab it had become by that time. There were three divisions with 135 people. WE had the control dynamics under Scolfield. Structural dynamics under Ryan. We had aerodynamics under Dodd. After a couple of years, when Dysler came to the space science lab, he wanted to get rid of Bill Vaughn's atmospheric science division. He tried to get me to take the ones that he didn't want. He wanted the scientist, he didn't want the engineering people. We cut a deal so that the people could go where they wanted. He didn't want that function of the engineering people had. So we let them all vote which one they wanted to go. Only one guy stayed in SSR. Which is sort a bitter pill for him. Anyway I got a new division. They all came over to my place and we just had the same atmospheric science division.

Then after Challenger, just before the S-13, I don't remember what year that was, 1987 I guess, they decided... they had broken up the old analytical division from Structured



Propulsion previously except the thermal people plus formed a whole new life support group. They sent those over to George Hopson in the Systems Lab. The stress guys stayed in the PP, the Propulsion Laboratory. Then they decided to change that and took all the stress guys and thermal guys. No, they sent the stress guys over to my place. So we mixed them in with the structural dynamics and had a Structures Division which got to be over 100 people. Later they decided to break up that division of Hopson's. So I got Jerry Vanaman, all the life-support, and all the thermal people and formed that group.

14. WARING: Were all these changes going on because of trying to cope with unique problems with the shuttle?

15. MCDONOUGH: I don't know why. Suddenly I got everybody. I also got Clyde Nivens design division. When they reorganized all they left was Propulsion. I got all the vehicle engineering people. So I had stress, thermal, life-support, structural design. All those people. The character of our lab changed.

In the meantime, we got so big we sent the environmental guys back to the Space Science Lab. Dessler had left, Inard [369] got the job and he was happy to have them. The lab still went from 135 to about 400.

Then Wayne asked me to come up and take the deputy job up here. I almost didn't do it. I almost retired. In fact, to tell you the truth, I almost retired in 1981, right after I got into that job down there. They had an early out opportunity. I had a couple of good job offers and I almost went. Camebro [380] talked me out of it. I came up to tell him good bye.

16. WARING: I have a bunch of questions for you, now that I have a better understanding of what you have done. Can you tell me about systems engineering at Marshall and the

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creation of that systems engineering office? What was unique about the systems engineering at Marshall?

17. MCDONOUGH: You mean different from how other people do it?

18. WARING: Different <sup>from</sup> how other people do it. Or is it different?

19. MCDONOUGH: I don't think that it is different. Not now. I think that we have settled down into a standard pattern of systems engineering that you find in a lot of places; the Air Force. We are not much different. They are more paper and we are less, but we do requirements. What you see systems engineering doing, it usually is the same way. You start out with a project and you build the requirements that you have to go with for the project. If you are building a space vehicle you have to know what it is suppose to do. You start out with functional. Functions and then you work from functions to top level requirements. You go down through requirements and fan them down to their lowest levels. Then when that gets split up, there is the integration side that all those jobs are split and then you <sup>b</sup>ring them back and focus them into the finished product. So all that takes place. We have an aberration in the middle where we had divisions which were project divisions; like space station division. That was back more like the old central systems. I had a group for one project inside the laboratories. But now that we are back to norms, I would say that it is not much different.

20. WARING: But it took a while for Marshall to develop a central engineering organization? Why did it take so long?

21. MCDONOUGH: Well, its not obvious what is the best way to do systems engineering. I really think that we way we are doing it now is not as good as the way it was under ~~R~~<sup>L</sup>udy.

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The way Rudy set it up, there were only a couple of hundred people involved. Maybe a hundred in his organization. We weren't big enough to get in anybody's way. We were the bees that cross-pollinated. We weren't trying to control, we were trying to shape and make sure nothing was left out, all the wires were plugged in and that sort of thing. We had a lot of teams and panels and boards and things that worked between centers. We were involved. I led one of those. Several other people did that to pull it together, but not to control and so on. When they made that decision to go to central systems engineering...

22. WARING: That was about 1968 or 1969?

23. MCDONOUGH: Yes, it must have been 1968, the big issue there was were we going to impose a big systems engineering charge. All of the engineering reports to systems engineering, in essence it is a management job. So we had in central systems organizations that paralleled exactly the laboratories. If there was an astronautics laboratory, we had a little astronautics lab right there doing work in parallel to those people. It was terrible. Doomed.

24. WARING: The central engineering office was doomed?

25. MCDONOUGH: Yes, it was doomed from the beginning. It couldn't soak up that much resource doing that job.

26. WARING: Because the labs had automatic responsibility for their problems anyway.

27. MCDONOUGH: Sure. We found ways to work together. One reason I brought up that thing about the working group in structural testing or dynamic testing, there was P&GE, Astronautics and aeroastronautics. Equal partners. It was a triple-headed panel. I

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was the secretary. I ran the place. Just like my secretary runs this office. Because you do the day to day work and they make the decisions. It was good. They would come together once a month and make decisions. I didn't run it alone. I had counterparts in the laboratories and we just talked together, reached conclusions. We worked together. Everyone knew that's my job and that's your job. We would just come together and do it. Marshall worked beautifully well. The idea that von Braun set up was automatic responsibility, was perfect. I think that if you realize what your job is and know how to do it, and find like-minded people in their areas, you can come together. There was talk about the shadow organizations. One to chart and the other one that works. You could transfer people to the most outrageous jobs and people still [?].

Take Walter Hausserman for example. I was sitting up here and I had a problem with very low temperature gyros, something that we were worrying about for another application, another center.

28. WARING: This was during Saturn, during the 1960's?

29. MCDONOUGH: This was actually about 1970. I just asked Walter, I figured he knew the most before, sure enough he had kept up and he was just encyclopedic. He came up and drew the curve from memory on the board, explained the whole thing. That's automatic. That man always knew who he was and always worked that kind of work, no matter what else he had to do. He always made sure that he was on top of his job. That's worked pretty well. We had I think another run at making systems engineering superior to other things when we formed these...[end of first side of first tape]

....those people from that division would go over to the reviews in Europe where they were being built. The good dynamists could never go because there was no travel money for him.

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30. WARING: It was these general systems engineers rather than the specialists who went.

31. MCDONOUGH: Some of these are good people, but nobody can be good enough to cover two or three areas in depth. I am not going to take anything away. They are pretty good people. It is just the idea that somebody could go and represent a whole bunch of different aspects of the problem. It just doesn't work. We knew that before, we had to learn it again.

32. WARING: Why do you think that there is a tendency to have systems engineering centralized? Because it is seen as a managerial function rather than a technical one?

33. MCDONOUGH: I think there has got to be some tendency along that direction or we would never do those things. It could be some empire building by people who have the job down there. I think that when Thomason had it, he definitely was an empire builder. Its a good way to do that.

I think that Bill Lucas felt that it was a management job to some extent, too. I can recall when he looked around the room, we were having some Hubble problems at that time and said, "Who was in charge of the engineering of this project?" There was no, other than the chief engineer, he wasn't talking about him. He was talking about down in the laboratory. He finally got Hopson to stand up and say, "I guess I am." [Lucas said] "Alright." The next thing you know he had this army swarming over it, working at a higher article fashion.

34. WARING: That's a very interesting management problem for these R&D projects. Do you think one reason why it was more easily solved in the Saturn is that you were working with one big piece of technology and there was a lot of experience and could test these things so thoroughly?

35. MCDONOUGH: Yes, I think so. But I also think that, one: We had enough people to work on the project. Plenty of people. We could squander people doing useless things. There still were a lot of wars over turf and things like that. But there were still enough of an army to do the job. I think that when you get short of people is when you feel the pinch. That's the difference. Then you have to be a lot more clever with how to use the resources that you have. We are going back to the old way. TQM is a boom to us for continuous improvement. What I am trying to do in S&E now, is to force decisions and responsibility down as low as you can force it and stay responsible yourself. The boundaries between laboratories shouldn't be crisp, war zones, you know. People ought to just mix and naturally come together and solve problems. It shouldn't be up, over and down. I will say that the thing when Petrone took project offices out of the labs, he did get rid of that one thing that the squabbling was up there between the lab projects office and the project offices. You had to feed your material up to them, so the war could go and the other people would heat it up and they would squabble and results would come down. There was too much of that. Not everything was done that way, but there was a lot of squabbling.

We had lead laboratories, that was the other thing. On Skylab total abortion, where other labs would work for you. You were in charge and they would work for you. I think that this TQM, we are starting to see it work. The lab guys are beginning to get together and talk about interfaces and problems that need both sides to work, thinking of each other as customers. All of them good thoughts. If that works you have a lot less need for systems engineering. You go back to [?] that's what I see.

36. WARING: You don't have to have specialist doing systems engineering. People are working it out on their own?

37. MCDONOUGH: Yes, the specialist are connected. You have people up there making sure all the connections fit, everything is consistent, looking for gaps where the connection hasn't been made.

38. WARING: Evidently in the 1970<sup>s</sup>, if I am understanding this, there were system engineering specialists and that was their job.

39. MCDONOUGH: Oh yes. Well, there will always be some of those because there is a speciality that is systems engineering. What I saw in the 1970<sup>s</sup> is where you had the lead guys in structures would be in the systems lab not in the structures lab. The guy calling the shots about structures was not a working structural engineer, he was a working systems engineer, whatever his background. That was up until very recently, people were talking about that, the very best dynamics man ought to be in the systems engineering laboratory leading all that work. That's some of the people who are in charge now, had thoughts like that at one time. I hope that we are out of that.

40. WARING: What taught Marshall the lesson that the centralized system of engineering was not the best way to go? Do you think it was just problems in the shuttle and the telescope generally?

41. MCDONOUGH: I am not sure how we got out of it. We didn't just rush out of it. In fact, I was so busy with other things that when they finally disbanded those things, I wasn't really involved in the thought processes. I busy doing post-Challenger and other things trying to shape this lab up and make something out of all these people that kept coming over the wall at us. I think there must have been a realization that it was wasteful, that it wasn't working right.

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42. WARING: You had a middle man do something that two technical specialists could do?

43. MCDONOUGH: Yes. Well, they put out or tried to put out a document about how we do systems engineering in S&E when Jim Kingsbury was in this job. I non-concurred in it. I don't know how many other people nonconcurred, they give you separated signature sheets. But possibly a number of lab directors non-concurred. They have it all in the black box, classical Air Force engineering, black box A is this guy; black box B is this guy; systems engineer grabs the wires and bolts them and plugs them in. I said, " we are not talking that, you tell me how a systems engineering lab gets in between Bob Ryan, Werner Dame and Harold Scofield in working with control of the vehicle going through the atmosphere and trying to point or aim or do something. Those guys work their people. They are mixed up in one room and a systems engineer would be totally lost in those detail discussions. If he is capable of dealing with the discussion he should move from one laboratory to the other and get involved in the discussion. I tell you, that persistent, it has been within the last two years that we broke that idea and largely when Ray Tanner left my old job before I came up, Tanner wanted to do things the old way. You have a dynamics working group between us, Martin, the Italians and Houston on the Tethered Satellite and he wanted that to be headed by a guy at the Systems Lab, to stand up and talk for the dynamicists. Crazy. They also had a systems panel.

44. WARING: Essentially it's another layer of bureaucracy. You have the project manager, the systems engineering, and then the people at the bottom with the hands-on experience. Right?

45. MCDONOUGH: Don't forget that you also had the chief engineer.



46. WARING: The chief engineer's office.

47. MCDONOUGH: Yes, so that is another layer. Project manager, chief engineer, finally you get to somebody doing the work. But that idea persisted a long time. Tanner came out of space station. I think that Jack did feel that way. I think that you<sup>r</sup> perspective changes as you move. Then you see it differently. I wouldn't have expected him to come up with that idea today.

Within the last seven or eight months, we had a meeting with S&E about how we do space station. Still, we are rooting out that idea that was embedded down in the systems lab in the GSE (Ground Support Equipment). Then we had MGSE and EGSE, mechanical and electrical. Mechanical was done over in the EP lab and the electrical was done in the EB, and damn if there wasn't a systems guy for GSE to pull them together. So we cut him out of there.

We also had a big function in the chief engineer's office doing operations. But there is only one lab involved in operations since we restructured and put Fletcher Kurt<sup>s</sup> in that lab. Why have this big organization dealing with just one lab? We just cut out most of those people and just let Fletcher Kurt<sup>s</sup> and his people deal directly up with the project.

48. WARING: This has been done in the last couple of years?

49. MCDONOUGH: Last year, since I have had this job. We have done all of that since I have been here. So we are going more and more that way, looking for places where there is nothing but pulling together two guys that are perfectly capable of pulling themselves together and get those people out of there. We need them elsewhere.

50. WARING: A flatter organizer now?

51. MCDONOUGH: Yes.

52. WARING: You mentioned the shift from having lots of people to having about half as many people. How did it change the labs to lose some of the blue collar technicians, the machinists who were either in-house people or...

53. MCDONOUGH: You wanted to cry about that. I tell you, Gene Cagle took me over to his shops one time when I over there, when I was up in the chief engineer's office and Gene said, "Look at this. We have unique capabilities here. Jim Kingsbury just decided that we had to get rid of those guys." The cuts we had, somebody had to go. He said, "We will never get them back. We will never build this capability again. Von Braun created something out of nothing here. We trained these guys. Those old Germans that came over here were masters." A guy like [?] was unparalleled. I never knew a man like him before or since. Just unique being able to do these jobs. They trained up these guys. I don't know what they were before. I guess just your usual kind of people that you find living around a place like this. But eminently trainable, just like a lot of people if you give them the opportunity. But anyway, that tore up to pieces. We couldn't do anything anymore. Our shops went, our technicians went. But on the other hand when we got rid of the support contractors, I think that was one of the most brilliant things that anyone ever did around here. I guess Kingsbury made that decision as far as I know. I could be wrong, but I think that he decided that originally.

54. WARING: Why was that beneficial?

55. MCDONOUGH: Well, because we had so many support contractors that all too often we were just managing support contractors. So the organization was all listening and there was a contractor doing the work, with more or less direction from them. They are pretty

independent in a lot of ways. The people also knew that the support contracts that project manager and support contractor knew S&E. We got to be superfluous. I think a lot of the wrong people got promoted because the singers and dancers got promoted, where the technical wizards weren't needed. Suddenly you are thrown out on your own resources where people had <sup>to "root, hog, or die"</sup> ~~a rule log or died~~. Suddenly you found out who was good and who wasn't good. There was a culture shock, but people just like working that way better. When they got back in the saddle and doing things, you could never go back to the old way. It was a joy to watch people come to life. Now a lot of them never made it. A lot of them just sort of sat there in the dark waiting for their time to be up so that they could leave. But the vast majority adjusted well.

56. WARING: But when many of these in-house machinist and technicians left for some of the model construction, I take it you had to go to contractors.

57. MCDONOUGH: Of course you got the same guys back.

58. WARING: You got the same guys back? Weren't there layers of red tape and bureaucracy.

59. MCDONOUGH: Yes, sometimes. I mean the government tries as hard as possible to put bureaucracy in your way. In fact I was just looking at the C&F. We are getting charge 5 million dollars for a building I wouldn't be willing to put my life on the line. But I could walk off this Arsenal and say I am not government, I want that building for 1 million dollars and have people beating themselves to death to get the job.

Oh yeah, they made it tough and until we turned around and brought a contractor in, VerVall [?] to do some of that shop work, now its alright we can direct them just like your civil servants. We are moving back closer to where we were. It was terrible trying to

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get anything done. In a bureaucracy all these, I don't have to explain it to you. It self-perpetuates. It always looks for problems to create so it can assert itself somewhere to get in the way.

60. WARING: Can you think of some examples where there layers of red tape might have made a difference in how things were done? In the long run does it make much difference or does it just slow things down and makes thing more expensive?

61. MCDONOUGH: Well, I think today that if you look at the way people spend their time, you would find a fairly large portion of this in S&E workers, that say they spend 1/4 of their time worrying contracts just to get work done that they need done.

62. WARING: Filling out forms, monitoring....

63. MCDONOUGH: Filling out forms and going over and talking to the procurement people and doing this and doing that. All too much time on doing things like that. If you want to get a facility build, we have a facility's office. We have to stroke them and worry about things. It's much more work than if we did it ourselves.

64. WARING: Do you think there is any possibility in going back the old way?

65. MCDONOUGH: I don't know. I saw the first glimmer of hope from the Army of all people, who is much more mature than NASA's bureaucracy. But then have started just this year a program where they tried to give the head of engineering, McCorkle, who is my counter-part over in the Army runs that laboratory, give him the same kind of power as the Director of Engineering that his counterpart in industry would have. He does his hiring, his firing, his procuring, his legal. He's going to have all that. I don't know how they are going

to do that. But, if it goes the way I have heard, I am going to have to explore this more, that would take care of it. I have got my guys telling me now where S&E does the facilities job itself, which we do some of, not much. It has to be small and so on, no problem. People can do it standing on their head compared to what it takes if they have to work with facilities. Because the people that are suppose<sup>d</sup> to be helpers have become the watchers. That's bureaucracy. It was the same in S&E, we are trying to reverse it, but it was the same there. If you take the helpers in the labs and those projects jobs and send them up to EM, which is management function, suddenly they are telling you what to do, not doing it for you. They are setting ground rules, "Here's a 424 fill out all these things and submit in triplicate." So we are trying to backtrack. It's better to light one candle.

66. WARING: Another change for the labs and the science and engineering directorate in the 1970's was that they were all involved in a lot more projects than they ever were in the 1960's during the Saturn years. Can you describe some of the causes and consequences of being involved in multiple projects at once?

67. MCDONOUGH: Of course the causes were that Marshall was in great danger of being shut down. When your projects over there was a strong push, I heard that there was everything all the way up to a Jewish conspiracy because there were Germans here! I actually heard that.

68. WARING: Even at the lab level people were trying to find stuff to do, new things.

69. MCDONOUGH: Sure. That is why we all like things like Skylab. Then they came up with some of those things like payload integration and small projects, things of that sort. That's really why we got into remote sensing I was doing. That was just ways to keep people working, to spread out our base of projects.

70. WARING: Did Marshall have expertise in that sort of stuff? I mean a lot of this was geology experiments.

71. MCDONOUGH: We had geologists. We had everything here. Its amazing what we had. When I was in that Environmental Applications Office, we had a geographer, a geologist and all sorts of people like that. We had a lot of talent to get into these other areas, especially when we got into small experiments and things. We had good scientist which we never really tried to use before. It was sort of a playground to play on, they were doing good science, but it was never focused on the center. Science for its own sake. They were all doing science but it was not what can science do for the center to get projects.

72. WARING: They were doing research for publishing purposes?

73. MCDONOUGH: They were doing a lot of research. Of course they had PEGASUS and other things through the years. It wasn't all that way. I don't want to make it sound like they were frittering away time, but people started focusing with the talents we got what can we go after. That made good sense. They started thinking seriously about those things. So a lot of people came in and got that thought process going. That was good stuff. It was exciting times.

74. WARING: Do you think that it raised the status of scientists?

75. MCDONOUGH: I think it raised their status amongst their peers. When Dessler came in, he decided we should be a Harvard and back out of all that again. A lot of those scientists, you know there is not pure science and pure engineering anyway. In fact, I just read an article up here, I read something. Take a second and read it because I am going to

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give it to Jack. The guys writing about scientific methods and statistics and so on. He said, "science is not any particular method or set of techniques, its a way of reasoning. Standards are intellectual rather than procedural. Method of observation, formalization and testing must vary with the nature of the problem." He is just making the point that science isn't different from engineering, it isn't different from medicine really. All these things take a structured approach to thought and then what are you thinking about. I am thinking about astronomy, you are thinking about building a structure. ~~It's~~ all the same kind of thing. When [?] Yancey got in there and we started pulling back in and trying to get them involved in center programs, I think that is working pretty well.

The problems you alluded to though are hellish problems. How on earth, given that you have a shuttle that is all consuming, do you really keep continuity and purpose in building a small experiment~~x~~.

76. WARING: People are continually being pulled off the one project or another?

77. MCDONOUGH: Yes, so their response, especially what bloomed under Desseler was that you put all the resources in the Space Science Lab, mechanical engineers, electrical engineers, data people, you name it, they are all over there. They have a team and are a little S&E all to themselves. Until I got in this job, we still don't have...in fact it's not finished yet we are still working on it to break that. There are people over there, lead scientist that see themselves as project manager. I am in charge of this damn thing and I will break the job up and give this to contractors, this to universities. Here's the scut work that I will give to S&E. That isn't all scut work, but they are going to decide what S&E ought to do and not to do, whether they should be involved or not involved. They are essentially making center director decisions down at that level. We are going to have to stop that. But the nightmare has been that when you go to an institution like we are and you try to matrix people and there aren't enough people to go around, you<sup>are</sup> always bouncing

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from here to there. There are fire drills and panics and all that mess its kind of wasteful too. We are struggling, but hell, that is an opportunity too.

78. WARING: Because of all those changes in NASA generally, and Marshall in particular in the 1970's, proliferation of projects, cutbacks of personnel, do you think in many ways it was almost like a new agency? Or do you think there was a lot of continuities from the Marshall of the sixties?

79. MCDONOUGH: I think that there was a lot of continuity. The same way as looking at problems. The same way of thinking about things. The idea of automatic responsibility never got killed. It got burgeoned somewhat. Like I said, those guys found themselves, there might be a system guy out there trying to do it, but those guys down here are still working the problem.

80. WARING: Do you think Marshall still has the mentality of being conservative engineers like they did in the sixties?

81. MCDONOUGH: Yes, too much so probably.

82. WARING: Why do you say that?

83. MCDONOUGH: Well, every time you add a pound of structure you lose a pound of payload. I think we are on the conservative side. It was getting better until Challenger. Then everybody hunched up and the rest of the agency...well like the safety people at Houston are more conservative than we are. J.R. has got us together now all the heads of engineering and quality to talk to us about some of these problems. That's when he is going to have to deal with it. We are going to have to get our courage back, or our sense



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back or something and say, you can't sustain the Challenger and it might happen again and its alright. It is better to have another failure than you just give up and do nothing. You know we only fail when we try. But I think that we are a long way from failure with these things. We are very conservative. We don't <sup>accept</sup> ~~except~~ other centers' engineering. They don't <sup>accept</sup> ~~except~~ ours. We have to do it our way if you want to fly Spacelab. We have to do their way if they want to fly on shuttle. We have got to find some way to cut that back. I think reasonable people, especially if J.R. is helping us. I hope he is, he hasn't committed himself to what he is after.

84. WARING: The relationship between centers is an interesting problem. Is there a different approach to engineering here at Marshall as opposed to at Johnson?

85. MCDONOUGH: Johnson is all contractors. They are what we were before we got rid of our support contractors. I think that they are now trying to get back to closer what we are, trying to become an engineering force. But they have their engineering in the budget columns, pick up the phone and call a contractor. Level II's a good example on the shuttle. Armies of Rockwell people come out of the <sup>ir</sup>midst to deal with your civil service. So they have a long way to go. I think that Aaron Coleman recognizes that he needs to change. His S&E looks a lot more like us than before he was there. He is changing equipment, putting McKowen down there with Henry Pohl and getting their science and engineering right. I think that we have the right way to do it. We get a lot of abuse by people who... There are people on the outside, the contractors, who would like us to work like the Air Force. They give you the money; you go away; you deliver a product; they buy it.

86. WARING: Make Marshall into a bunch of accountants essentially.

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87. MCDONOUGH: Yes. The natural tendency of the government is to hire more procurement people, we are hiring more environmentalist, hiring more <sup>bureaus</sup> buyers of that kind of thing [?]. More managers, less muscle. More fat, less muscle. But we have resisted a better than a lot of people. Certainly better than the military has. It goes back to von Braun. You asked about the continuity. I think that idea has been written inside us somewhere, that the way we do it, that's the way to do it. We have to be as smart as the contractor or we are going to just get taken to the cleaners like the Air Force did. We have to be able to sit down and eyeball to eyeball talk detailed technical problems with those guys.

88. WARING: One of the engineering difficulties that seems to me that Marshall has had, is that they do not have control over mission operations and it seems that often that control over the overall technological systems seems to go to the center that has control over mission operations like Johnson and the shuttle or Goddard and the satellites. Do you think that is an accurate portrayal?

89. MCDONOUGH: Well, I think that the publicity certainly goes there. The operations job certainly entails kind of an oversight during that phase. But you look at the shuttle and our role in that thing, building the flight readiness <sup>reviews</sup> ~~reviews~~ and so on, ~~its~~ just not Johnson getting up and speaking to the [?] elements, ~~its~~ Marshall. Our job is just as strong as it would be without the Level II. We get up and speak ourselves. Now we may get second-guessed and have to go fight with those guys. But I think in that way we still have a strong role in the operation. In Hubble I think we made a mistake in handing off operations. That is kind of awkward. But I noticed now that we had a case come up where they are asking us to characterize what is wrong with the mirror and what we can do about it. Design changes. Well, supposedly this month, the end of this month, the Hubble goes to Goddard. ~~Its~~ <sup>their</sup> ~~there~~ problem. But even Goddard didn't want to take that part of the

problem. They say, <sup>u</sup>Well, Marshall did all of the engineering work. <sup>o</sup>It's right that you guys go on and finish this job and take responsibility. I find that very promising. I wasn't sure that they were going to do that. That's just the way it ought to be. Sustaining engineering. We built the thing and to some level we should keep the corporate memory of how they work, and be called in when things happen and so on. There isn't much pure operations.

No, our problem is the other way. That we still have Spacelab flying. We do have that operation. We have little experiments going. We have astros. Not little. We have other things, tethered satellite. We have CRESS up now, that's another team operating that. We have got the scientist team. We don't have the operations team of pulling the levers and pushing the buttons, but we have got the guys in science calling the shots. We have the people getting the science data out to the community. With the observation system, we are going to have node on that big data system that Goddard is building. We are going to have our own user community and we are going to service them. On XF we are going to have the whole operations job. The biggest job of all, Space Station, we got it. We have the most horrendous job that has ever befallen us! I don't want it to tell you the truth.

90. WARING: So Marshall is getting control over operations.

91. MCDONOUGH: More than we want.

92. WARING: But that is happening in the '80's?

93. MCDONOUGH: Spacestation is just going to kill 'em. If you look at the agency you can see why this is happening. The agency is spending more and more of its money on operations. There is no room at all for anything new anymore. This new initiative has to

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be on top of all of this. You are going to have space station out there three hundred and sixty-five days a year.

94. WARING: It is going to take a lot of time just to keep the shuttle running.

95. MCDONOUGH: The shuttle running and we are going to be doing other things. Even Spacelab won't go away. We are going to have all kinds of things.

[End of 1 of 2 cassettes]

96. WARING: ....as being a sort of decline from the Saturn years. The great success with the Apollo Program and with Skylab and then Marshall and NASA lost confidence. They lost them, they lost the heroic programs. But you don't feel that way?

97. MCDONOUGH: No, I think as far as raw talent goes, we are as good as we ever were. As far as experience goes, they had no experience either. You know those Germans were wonderful people and very talented people, but they came here and what did they get? They got what they found around here. Its no better or worse than if they had gone to Iowa or someplace. But you know there weren't people flocking in from the MITs and so on to come here. Again, I don't think MIT is that much better than the University of Alabama for that matter. But I am just saying is they were not drawing broadly the best this country had to offer to come do this. They were building on the resource they had. These people responded well. They were good people and they learned. Good tutelage, they came along. This roothog, or die idea ain't bad. You know, throw them into the lake, see who swims. The ones that don't well, we find places for them. For those that do, you throw them into a deeper lake farther out. They have always done that and we are doing that now. I am pushing hard to give people a chance to fail. One of the reasons I like to do

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these little projects that come in the Space Science Lab. Do a few of those in-house. Put the young people on. Don't give them a lot of help. Don't stand over them and say, "take your left hand here." You say, "Go build the damn thing. Design it, wire it, build it." We will see how it works. If it doesn't work we all are going to learn a lesson. There is a little breakage, but hell, its breakage on a million dollar project, not a billion dollar project. But I think if anything, we are getting better people on these projects. Especially since Challenger. The only reason I say that is that we are drawing more broadly geographically than we were. We are really getting candidates more to put from. I know when I was first in the lab, we took some people I certainly wouldn't hire now. I have got some people now that I can't believe are coming, really good. Some people, just straight A students practically from good places. We have people, like one professor from MIT called me trying to place some people. He got to know us down here working on Challenger. He came down here with some black thoughts about what was going on here. But they see what Marshall has and what kind of job they have done. They are impressed, word gets around. Good people like to go where there is action. They didn't even know there was a Marshall, a lot of them. I am real pleased with the young people. The only short coming I see is that the schools are making one fundamental error in engineering. They are turning out what I call piano players. Our own children are a good example, people who are tremendously skilled at computers and things of that sort, but they have never had to work with a slide rule and they don't know how to get a 99% answer or a 90% answer in a minute. Most of these old guys can tell you, "well, that's about give or take  $\lambda$ " Somebody that brings in an answer that doesn't look like that, well, we are going to talk. But some of these younger guys don't know what the answer ought to be instinctively. That's what we are trying to teach them. That's why we have got to get them on hardware. That's where you learn it.

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98. WARING: Is it a lack of hands-on experience? Like that "dirty-hands experience" that von Braun talks about?

99. MCDONOUGH: Yes. We all believe that we have to find in-house jobs. That's the frustrating thing. We have so many jobs that you can't do that on. You have got to watch Spacestation. You don't get a lot of in-house there. Except the environment. We need a lot of these little things to train these people up. Let them fail. You never forget a lesson you learn that way. "That burned out early, you're not going to that to me. Don't give me that story!" You know it doesn't work.

I just feel real good about Marshall. Oddly enough, we are weakest probably in systems engineering. Just so many of our old hands retired all at once, just left. We are making some moves now to pull people out of the other labs to fill in. People who know the techniques<sup>gues</sup> and put them in some of these jobs in that lab or find ways for them to do systems engineering where they are. Just to fill in that experience gap.

I feel real good about Marshall. People are coming to us more and more for jobs that they want done. I just finished a job doing a non-advocate review for an airplane program. They asked for somebody from Marshall to do that. I thought that was pretty nice.

We are well managed. Our weakness' are that we have to respond to the bureaucratic realities. What can you say about that?

100. WARING: If there is no money, there are no people<sup>2</sup>. You have to adapt.

101. MCDONOUGH: In the old days, I know the old-timers, a lot of them say...first of all they<sup>were</sup> ignorant about what was really going on. What von Braun was doing, what Congress and all that. That was going on in a different place. Now that is very obvious that congressional staffs are all over us. They just had this one glorious thing to do. They were

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pioneers. There is nothing better than being a pioneer, you know. The first one to ever enable man to get off the surface of the earth. That is terrific, I am proud of that. I get fired up thinking about things like that. There is no other job like that. Going to Mars is just another place off this earth. Going to the Moon was the premiere happening of mankind in recent past. Maybe a thousand years, I don't know. You just do it once. Von Braun characterized it that it had the same significance as the first creature crawling up from the sea and living on land.

102. WARING: But it was hard for Marshall to follow that up. Hard for NASA to follow that up.

103. MCDONOUGH: Right. What do you do for a second act?

104. WARING: ~~1. WARING:~~ That's right. Putting a satellite in orbit or building a shuttle is not nearly as dramatic.

105. MCDONOUGH: There's nothing like that. I think when man takes a permanent abode in space, when we really have people in space that never come back to earth, that's the next step of the same size. I think that is what you have to go to. When we start another civilization that has never tried the surface of the earth. That will be a while.

106. WARING: Is there anything that we haven't talked about that you think the historians of Marshall should know?

107. MCDONOUGH: <sup>I'm</sup> Sure there are a lot of things. In those topics, these are my feelings about it and where I stood.

108. WARING: That is what I wanted.

109. MCDONOUGH: A lot of good people have been at this center and still are at this Center. I think if I do say so, Marshall is the heart of NASA<sup>a</sup>. As far as engineering goes. Science you might say otherwise. For special things, there is nobody like JPL for planetary probes. I would say that maybe JSC has the edge on us for managing big projects. They pulled the whole shuttle together. The management part of it, they may well have done as good a job as us. [?] Sometimes engineering is just something that you can rely on. This is the way it is. That is the way with von Braun and everybody else. Most of us that were here in those days feel very conscious of that.

110. WARING: But it wasn't until the 1970's that the Center burst forth from being just propulsion center to being as you say the engineering center.

111. MCDONOUGH: Yes, that is when the change took place. Of course the engineering that was being done in the 1960's was the propulsion and the life support. Those were the two things. JSC had the command module, we had essentially the rest of the vehicle. That was a natural split. But we did the biggest structures, the newest engines, and the biggest engines. When we went to the shuttle, the same thing happened, we did the SRB's and the ET. There is the orbiter sitting there, the airplane that Houston did. I was pretty proud of that. That was kind of my job to make sure nothing happens to that legacy. I feel very strongly about that.

But to me the main problem facing us other than making these young people part of that feel, whatever you want to call that, to pass the torch on to them. The other thing is to get our efficiency up. I can't do anything about hiring more lawyers. Whatever demands force that to happen. But I can do something about getting more out of the people that we have at S&E. One of the best ways is to keep the bureaucracy off their back.



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112. WARING: That's how they do in government, the university or anywhere.

113. MCDONOUGH: Yes, I'll tell you, I got one of the nicer notes. A fellow recently retired who worked for me as a division chief. I was the Lab Director. He really wanted to thank me for putting the bureaucratic necessities in the proper perspective. We don't give them a bit more than is required. You do what you have to. It's a real challenge. But hell, if it isn't a challenge it ain't quite right.

114. WARING: That's right. You have to keep searching for the challenge.